DEVELOPMENT OF SINGLE STATION LIGHTNING DETECTION SYSTEM

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ABSTRACT

The lightning strikes billion of times, kill many of people, and damages billion of assets per year. This problem may be properly managed by using a lightning detection system. In this project, the lightning detector circuit was designed by using PIC16F877A microcontroller. The purposes of this project are to determine the distance and direction of lightning strikes. One wire antenna and apair of loop antenna were attached to the circuit. A pair of loop antennas is used to sense the magnetic field produce by the lightning strike and a wire antenna is used to sense the electric field produce by the lightning strike. Three variable resistor will act as the antenna in this project to give the variety input to the PIC microcontroller. CCS compiler is a software used to write the program to microcontroller. The program written for Graphic User Interface (GUI) is done by using Microsoft Visual Basic 6.0. LED will blink and LCD will display the data of distance and direction of lightning strike. Meanwhile, GUI will display the results also with the add on of electric field and magnetic field values of each antenna and saveall the data in a laptop.

ABSTRAK

Kilat menyerang bilion kali, membunuh ramai orang, dan merosakkan bilion aset setahun. Masalah ini boleh diatasi dengan menggunakan sistem pengesanan kilat. Dalam projek ini, litar pengesan kilat telah direka dengan menggunakan mikropengawal PIC 16F877A. Tujuan projek ini adalah untuk menentukan jarak dan arah kilat berlaku. Satu wayar antena dan sepasang antena gelung telah dilampirkan kepada litar. Antena gelung digunakan untuk mengesan hasil medan magnet oleh kilat dan antena wayar digunakan untuk mengesan medan elektrik yang dihasilkan oleh kilat. Tiga perintang boleh ubah akan bertindak sebagai antena dalam projek ini untuk memberi pelbagai input kepada PIC. CCS pengkompil adalah perisian yang digunakan untuk menulis program untuk mikropengawal. Program yang ditulis untuk Antara Muka Pengguna Grafik (GUI) dilakukan dengan menggunakan Microsoft Visual Basic 6.0. LED akan berkelip dan LCD akan memaparkan data jarak dan arah kilat. Sementara itu, GUI juga akan memaparkan keputusan dengan penambahan nilai medan elektrik dan medan magnet pada setiap antena dan menyimpan semua data di dalam komputer riba.

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LIST OF ABBREVIATIONS

LCD	-	Liquid Crystal Display
VB	-	Visual Basic
GUI	-	Graphic User Interface
CCS	-	Custom Computer Services
A/D	-	Analog to digital
PIC	-	Programmable Interface Controller
MCLR	-	Master clear
IDE	-	Integrated Development Environment
HEX	-	Hexadecimal
OSC	-	Oscillator
USB	-	Universal Serial Bus
UART	-	Universal Asynchronous Receiver/Transmitter
I/O	-	Input and output
LED	-	Light-emitting diodes
TOA	-	Time of Arrival
TX	-	Transmitter
RX	-	Receiver
EF	-	Electric Field
MF1	-	Magnetic Field for Loop 1
MF2	-	Magnetic Field for Loop 2

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CHAPTER 1

INTRODUCTION

1.1 Overview

Lightning is the one of the most unpredictable forces of nature. Any lightning strike is initializing with the polarization of positive and negative charges within a storm cloud. Subsequently, the polarization generates electric field surrounding the cloud. When the electric field generated is strong enough, it will ionize and make the air become conductive. With the conductive air, [1] charges in the cloud can be transfer to the ground and hence lightning strike occur.

The lightning discharges radiate electromagnetic pulses in a wide frequency range from a few Hz up to several hundreds of MHz. Particularly the intense pulses appearing at very-low-frequency (VLF) are called VLF sferics, which has been used to remotely detect the location of lightning strike occur. The lightning location such as theinformation of distance and direction of lightning strike has been performed by multi-station or single-station technique.

Multi-station techniques are the most accurate todetect the location of strike of lightning which is combining the magnetic direction finding and time-of-arrival measurements of sferics, as demonstrated by the U.S national lightning detection network (NLDN) [2]. In 1996, (NLDN) uses 106 sensors that located over the continental United States to achieve the accuracy of 0.5 km [3].

The single-station techniques use a single VLF receiver and give a more convenient way to locate the sources [2]. The direction finding will combine with estimation of the distance to the source. The earliest researches, they use the apparatus that includes a first loop antenna system for sensing the magnetic field produced by the lightning which signal is filtered, square rooted, and fed into peak voltage holding circuit [4]. A second antenna is provided for sensing electric field produced by the lightning which is fed into filter, an absolute value meter, and to a peak voltage holding circuit.

In this thesis, the lightning detection system was developed that is simple and cheaper than lightning detection system owned by Weather Forecasting Company or some others research company that huge in size and very costly. The method are using of one wire antenna and a pair of orthogonal loop antenna. The distance and direction was calculated using of formula deduce from previous researcher. The ratio between magnetic field and electric field is the method of determining the distance of lightning strike. The direction of lightning strike was determined by using of inverse tangent formula. The formulas showed in the next chapter.

1.2 Problem Statement

Lightning detector own by Weather Forecasting Company or some others research company usually very huge in size and costly. So, this kind of lightning detection system are seldom own by public individual. The information about lightning strike location is very important for public citizens to avoid them from danger especially the persons undergoing an outdoor activity. Therefore, to know the location of lightning strikes occurs, it is often desirable to know the distance and direction. Lightning detector which able to detect the lightning strike location occurred in a small radius with a small size and cheaper cost will be the first choice for the public citizens in protecting their life from the lightning strike.

1.3 Project Objective

There are three objectives in this project which are:

a) To develop portable lightning detector circuit where it is able to determine the distance and direction of lightning strike.
b) To develop GUI using Microsoft Visual Basic 6.0 to display and record the data.
c) To simulate lightning detection system circuit using Proteus.

1.4 Project Scope

In this project, lightning detection system is designed by using PIC16F877A microcontroller. The software used to write the program to microcontroller is CCS Compiler whereas the program written for Graphic User Interface (GUI) in between microcontroller and computer is done by using Visual Basic (VB) 6.0. The circuit of the project is simulated by using Proteus software. The interfacing between PIC16F877A and GUI will done through UC00A that is USB to uart converter. Besides data will display in VB 6, data of lightning strike also are displayed in LCD.All the data storing as .txt file in the laptop.

1.5 Thesis Outline

This thesis is separated into 5 chapters. Chapter 1focuses on outlines the main idea of this project. Chapter 2 would explained aboutlightning phenomenon, typical way of determining the location of lightning strike, and literature review of previous researcher. Chapter 3woulddescribe the methodology of the project, including the tools, equipments,procedure and processes involved for the hardware and software development of theentire project. In chapter 4, results obtained from the lightning detection system would bediscussed in this chapter. Chapter 5, which is the last chapter, would make a conclusion for this thesis and recommendations that can be used in further research related tothis topic in future would be included.

CHAPTER 2

FUNDAMENTAL OF LIGHTNING

2.1 Lightning Phenomenon

Lightning, an awesome and terrifying natural phenomenon, is really nothing more than an electrical discharge that happens to be at an enormous voltage. The natural hazard strikes billion of times, kills thousands of people and damages billions of assets per year. The sheer power of a lightning strike, combined with the brightness and intensity of the flash that comes with it make it one of the most gorgeous natural phenomenon in existence. The figures (2.1-2.8) are the most incredible shots of lightning in nature.

Figure 2.1: Volcano Storm

Figure 2.2: Sheet Lightning

Figure 2.3: Split Lightning

Figure 2.4: Desert Storm

Figure 2.5: Positive Lightning

Figure 2.6: Circle Strike

Figure 2.7: Ball Lightning

Figure 2.8: Multi-Strike

2.2 How Does Lightning Occur

Lightning is the result of a large charge separation within a cloud. Clouds are composed of millions of ice particles and water droplets. These particles collide with other condensing moisture as it rises, and when they do, electrons are knocked loose. These electrons build up at the bottom of a cloud and make it negatively charged. The rising moisture molecules, now missing electrons, become positively charged and gather at the top of the cloud. This creates a charge separation, which has an electric field that is negative at the bottom and positive at the top. As the collisions continue, the electric field builds so strong that it gives the planet's surface a positive charge. When these charges become powerful enough, the cloud's electricity is discharged toward the Earth's surface, which results in lightning.

2.3 Types of Lightning

There are various different types of lightning besides the standard cloud to ground strikes.

a) Cloud to Ground

This is the discharge from the negative lower part of the cloud to the positively charged earth. This is the most common form thought of when lightning is mentioned to people however it only constitutes 25% of all lightning however it is also the type that causes the most damage and so effects our lives the most.

b) Intracloud Lightning

Intra-cloud lightning is the most common form of lightning. It appears as a flash within the cloud occurring between the positive and negative charges that are within the same thunder cloud. Although this is the most common due to it causing very little danger or damage not alot of research has been carried out on it in comparison to cloud to ground.

c) Intercloud

The least common is the strike between the positive and negative charges within separate clouds where the strike travels in the between them.

d) Ball Lightning

This appears in the form of a glowing sphere which drifts horizontally in the air usually only lasting a few seconds. It is still not fully understood why this occurs, one interesting theory that was recently found was by Abrahamson and Dinniss in 2000 is to do with the soil type at the place of the strike. This idea comes in three parts.

i. A heated mixture with more carbon content than silicon can cause the silicon to separate out into a very light fluffy form which is capable of floating in air.
ii. The temperature of approximately 3000C where the lightning strikes.
iii. The mixture of carbon and silicon found in the soil.

So, bearing in mind the previous elements if lightning strikes in an area where the soil has the correct make up then a ball of silicon would be created and due to its light nature would hover in the air. The light emitted then is believed to be the oxidization of the silicon which would explain why the ball gives off such light and the fades away, as this would occur when the oxidization is complete.

2.4 What Happen When People and Lightning Converge

Men are struck by lightning four times more often than women. According to a study by Ronald L. Holle and Raúl E. López of the National Severe Storms Laboratory and E. Brian Curran of the National Weather Service from 1959 – 1994, males account for 84% of lightning fatalities and 82% of injuries, men can take comfort in the fact that the actual number of deaths and injuries from lightning strikes has decreased in the past 35 years.

Holle's team attributes 30 percent of the decrease in lightning deaths to improvedforecasts and warnings, better lightning awareness, more substantial buildings, and socioeconomic changes. They attribute an additional 40 percent to improved medical care and communications.

The National Weather Service publication Storm Data recorded 3,239 deaths and 9,818 injuries from lightning strikes between 1959 and 1994. Still, many doctors do not fully understand how to treat the injuries of the other 80 percent of lightning victims who survive a strike. Lightning injuries are not the same as electrical shocks. For one thing, the contact voltage of a typical industrial electrical shock is 20 to 63 kilovolts, while a lightning strike delivers about 300 kilovolts.

Industrial shocks rarely last longer than half a second (500 milliseconds) because a circuit breaker opens or the person is thrown far from the live conductor. Lightning strikes have an even shorter duration, only lasting up to a few milliseconds. Most of the current from a lightning strike passes over the surface of the body in a process called "external flashover."

Both industrial shocks and lightning strikes result in deep burns at point of contact, for industry the points of contact are usually on the upper limbs, hands and wrists, while for lightning they are mostly on the head, neck and shoulders. Industrial shock victims sometimes exhibit deep tissue destruction along the entire current path, while lightning victims' burns seem to center at the entry and exit points. Both industrial shock and lightning victims may be injured from falling down or being thrown and the leading cause of immediate death for both is cardiac or cardiopulmonary arrest.

If you survive a shock, you still have to deal with the consequences of the electrical burns. Industrial shock burns can lead to kidney failure, infection, muscle and tissue damage, or amputation. Lightning burns are exceptionally life threatening. 70 percent of lightning survivors experience residual effects, most commonly affecting the brain (neuropsychiatric, vision and hearing). These effects can develop slowly, only becoming apparent much later

2.5 Lightning Strike Locating Technique

Electrostatic field is generated when lightning striking on the ground due to the existing of electric charges. Electromagnetic field will generated with the moving electron which travels from the cloud to the ground. There are a lot research had been done on determination of lightning strike location. Basically, most of the researches are started by detecting the electrostatic field and electromagnetic field generated by the lightning strike. Besides electrostatic field and electromagnetic field, thunder storm is a famous characteristic of lightning strike used by the researchers in some lightning strike

locating systems. There are two parameters need to be determined in order to locate lightning strike location which are the lightning strike distance and its direction.

2.5.1 Determination of Lightning Strike Distance

The lightning strike distance can be determined by two methods that is by using delay in time of arriving technique (TOA) and ratio between electromagnetic field and electrostatic field. The TOA method is implemented by using two kinds of antennas which are wire antenna used to sense the electrostatic wave and the acoustic antenna is used to sense the pressure wave produce by the thunder storm when lightning strike to the ground. The pressure wave produces by the thunder storm is propagating with the average speed of around 350 m/s while the electrostatic wave is propagating with the speed of light. The delay in time for the acoustic antenna to sense the pressure wave compare with the wire antenna to sense electrostatic wave can be used to calculate the distance of lightning strike by the following formula by assuming the speed of electrostatic wave is very fast compare with the speed of thunder storm:

$$D = V_T \times T_D \quad (1)$$

where ,

D = distance of the antenna in meter

V = average speed of thunder storm which is 350 m/s

T = time delay between acoustic antenna and wire antenna in second

The method to detect lightning strike occurred using the ratio between electromagnetic field and electrostatic field consist a pairs of loop antennas and a wire antenna. A pairs of loop antenna is used to sense the magnetic field produce by the lightning strike and a wire antenna is used to sense the electric field produce by the lightning strike. Next, these two signals are then fed into a ratio meter to get the signal which is the ratio of the two input signal. The output signal from the ratio meter is proportional to the distance of the lightning strike.

2.5.2 Determination of Lightning Strike Direction

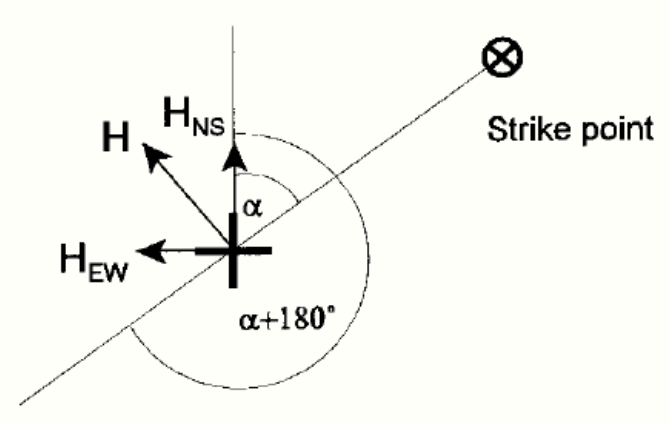

Figure 2.9: Determination of the Angle to the Lightning Strike Point